

Approximation of the 'True Unfalsified Set'

Citation for published version (APA):

Helvoort, van, J. J. M., Jager, de, A. G., & Steinbuch, M. (2006). Approximation of the 'True Unfalsified Set'. In *Proceedings of the 25th Benelux meeting on Systems and Control, 13-15 March 2006, Heeze, The Netherlands* (pp. 100-)

Document status and date:

Published: 01/01/2006

Document Version:

Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

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Approximation of the “True Unfalsified Set”

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1 Introduction

Typically, control design focusses on finding one value for the controller parameters, for a given problem. Unfalsified Control (Safonov and Tsao, 1997), however, tries to find the entire set of controller parameters, which are able to satisfy a given performance requirement.

Definition 1 (True Unfalsified Set) *The set of controller parameters, which satisfies the performance requirements (for a given plant)*

In Ellipsoidal Unfalsified Control (EUC) (Van Helvoort, De Jager and Steinbuch, 2005), an outer-bounding approximation is made of the True Unfalsified Set, using an easily computable ellipsoidal approximation. In a simulation, a comparison is shown between the True Unfalsified Set and the approximation thereof.

2 Simulation

Consider the plant $y(t) = P(s) * u(t)$, with

$$P(s) = \frac{0.01s^2 + 0.4s + 100}{s^2 + 4s + 100} \quad (1)$$

Also consider the controller

$$u(t) = \frac{1}{\theta_1} \left(r(t) - \theta_2 \frac{s+20}{s+2} * y(t) \right) \quad (2)$$

Here, θ_1 and θ_2 are the controller parameters and $r(t)$ is the reference $r(t) = \sin(\pi t)$. Then the closed loop steady state response $Y(s)/R(s)$ is given by

$$\frac{Y(s)}{R(s)} = \frac{\frac{1}{\theta_1} P(s)}{1 + \frac{\theta_2}{\theta_1} \frac{s+20}{s+2} P(s)} \quad (3)$$

The performance requirement is given by $1 - \Delta \leq Y(s)/R(s) \leq 1 + \Delta$, with $\Delta \geq 0$ a threshold on the allowable tracking error.

2.1 True Unfalsified Set

The performance requirement can be rewritten as

$$1 - \Delta \leq Y(s)/R(s) \leq 1 + \Delta \Leftrightarrow \quad (4)$$

$$-\Delta \leq Y(s)/R(s) - 1 \leq \Delta \Leftrightarrow \quad (5)$$

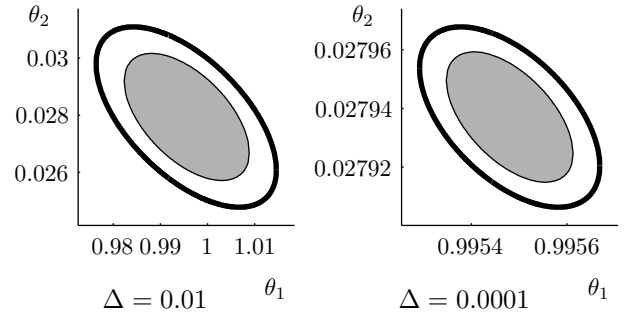
$$(Y(s)/R(s) - 1)'(Y(s)/R(s) - 1) \leq \Delta^2 \quad (6)$$

The performance requirement is evaluated at $s = j\pi$ (since $r(t) = \sin(\pi t)$). From (3) and (6), it can be seen that the True Unfalsified Set is an ellipsoid in the controller parameter space, with size dependent on Δ .

2.2 Ellipsoidal Unfalsified Control

EUC is a data-driven, model-free controller design method, which recursively falsifies controller parameter sets that fail to meet the specified performance requirement. An outer-bounding ellipsoidal approximation is used to describe the set of unfalsified controllers.

2.3 Results



True Unfalsified Set (grey, solid ellipsoid) and the outer bounding approximation, computed by EUC (black, open ellipsoid), for two values of Δ .

The distinction between the two sets originates from the outer-bounding approach of the EUC algorithm.

3 Remark

In EUC, the approximation of the True Unfalsified Set is used to select suitable controller parameters for implementation.

References

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